Clearance of bronchial secretions after major surgery

Leur, Johannes Peter van de

Are clinical observations of breathing and pulmonary function related in patients after abdominal surgery?

Johannes P. van de Leur [1,2], Peter Smit [1], Alida A. Broekema [3], Thomas W. van der Mark [4], Cees P. van der Schans [1,2].

[1] Center for Rehabilitation, University Medical Center Groningen, The Netherlands

[2] Northern Center for Health Care Research, Groningen, The Netherlands

[3] Department of Anaesthesiology, University Medical Center Groningen, The Netherlands

[4] Department of Pulmonology, University Medical Center Groningen, The Netherlands

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Abstract

Introduction

Decline in pulmonary function after major abdominal surgery is thought to be identified in daily assessment by observation of breathing and pain intensity. Measurement of pulmonary function is usually not included in the assessment of the patient in the post-operative period. The aim of this study was to investigate the relationship between clinical observation of breathing (COB) and decline in pulmonary function and the relationship between pulmonary function and pain.

Patients and methods

89 patients, admitted for elective major mid- and upper-abdominal surgery, participated in our study. COB covered the following parameters: 1) Abdominal expansion, Side expansion, High thoracic expansion, Paradoxical breathing, Symmetry of thorax expansion, Ability to cough, Ability to huff, and Signs of mucus retention. Pain intensity was assessed at rest (VAS) and during breathing exercises and coughing (VAS-F) using a visual analogue scale. FEV_1, FVC and PEFR were performed on the pre-operative day and for seven post-operative days.

Results

The correlation coefficient over seven days between COB and FEV_1 was 0.26 ($0.002 < P < 0.14$), and FVC 0.25 ($0.001 < P < 0.2$) and PEFR 0.19 ($0.001 < P < 0.49$). The correlation coefficient between VAS and FEV_1 was -0.22 ($0.007 < P < 0.642$), and FVC -0.22, ($0.002 < P < 0.548$) and PEFR -0.21 ($0.001 < P < 0.725$). The correlation coefficient between VAS-F and FEV_1 was -0.18 ($0.008 < P < 0.581$), and FVC -0.20, ($0.001 < P < 0.569$) and PEFR -0.22 ($0.001 < P < 0.794$).

Conclusion

A poor correlation is found between clinical observation of breathing and pulmonary function after abdominal surgery.

Introduction

Pulmonary function is impaired after upper abdominal surgery (Ali, Weisel, Layug, Kripke and Hechtman 1974; Johnson 1975). Ali (Ali, Weisel, Layug, Kripke, and Hechtman 1974) found a decrease of forced vital capacity of 63% after upper abdominal surgery. Ali (Ali, Weisel, Layug, Kripke and Hechtman 1974) and Johnson (Johnson 1975) found a decline of pulmonary function dependent upon site of surgical incision. This decline in pulmonary function is due to changes in diaphragmatic function (Ford, Rosenal, Clergue and Whitelaw 1993; Bartlett 1980; Simonneau, Vivien, Sartene et al. 1983). Reduction of diaphragmatic contraction (Morran, Finlay, Mathieson, McKay, Wilson, and McArdle 1983) and pain intensity (Taura, Planella, Balust et al. 1994) result in changes in respiratory movements. Daily assessment (Maitre, Similowsky and Derenne 1995) of the clinical pulmonary status is performed by physiotherapists. This assessment includes breathing pattern, ability to cough, and evacuation of mucus. Abnormal breathing pattern and severe pain are considered as indications for pulmonary function impairment. However, it is not clear whether this clinical assessment of breathing is a valid method to identify a decrease in pulmonary function after abdominal surgery. Regular pulmonary function testing in the post-operative period is uncommon. The purpose of our study was to investigate the relationship between pulmonary function and clinical observation of breathing after major abdominal surgery and the relationship between pulmonary function and pain.

Patients and Methods

After written informed consent 89 adult patients, scheduled for elective major mid- and upper-abdominal surgery, were included preoperatively. This study was approved by the hospital ethics committee. Patients included had an American Society of Anaesthesiologists (ASA) classification 1, 2 or 3. (Owens, Felts and Spitznagel-EL 1978) and were scheduled for Abdominal Aortic, Pancreatic, Hepatobiliary, Upper Abdominal (other), and Colonic surgery. Distribution, preoperative pulmonary function, and patient characteristics are described in table 1.

Table 1. Patients' characteristics.

	n= 89
Age in years, mean (SD)	52 (17)
Gender, male in %	55
ASA physical status in number of patients I/II/III	27/46/16
Type of surgery, in number of patients	
Abdominal aortic	14
Pancreatic	8
Hepatobiliary	16
Upper abdominal (other)	26
Colonic	25
Preoperative FEV_1 in l/sec, mean (SD) [% pred. (SD)]	3.0 (0.9) [91 (16)]
Preoperative FVC in l, mean (SD) [% pred. (SD)]	3.6 (1.0) [90 (16)]
Preoperative PEFR in l/min, mean (SD) [% pred. (SD)]	430 (120) [91 (20)]

Breathing was assessed during maximum voluntary inspiratory effort while the patient was in a semi-recumbent position. Every item was scored visually. If movement was met within the preset criteria than this item was scored as 1, if not than the item was scored as 0. By entering the scores in the equation a total score was calculated. The following parameters were scored as present, when the following criteria were met:

Abdominal expansion (AB):	Visible distension movement of the abdominal wall during inspiration.
Side expansion (ST):	Visible outward movement of the lateral chest during inspiration.
High thoracic expansion (HT):	Visible forward and upward movement of the upper chest during inspiration.
Paradoxical breathing (PARA):	Visible inward movement of the abdominal wall when the chest shows an outward movement or a visible outward movement of the abdominal wall when the chest shows an inward movement.
Symmetry of expansion (SYM):	Symmetrical movement of the left and right side of the chest.
Ability to cough (CO):	Ability to make a forceful expiration after building up a positive pressure with a closed glottis at a high volume.
Ability to huff (HU):	Forced expiratory volume with an opened glottis at mid to low volume.
Mucus retention (MU):	Presence of rhonchi during palpation of the chest.

Thereafter a total Clinical Observation of Breathing score (COB) was calculated by the following equation:

$$COB = HT + ST + AB + SYM - PARA + CO + HU - MU$$

The highest possible score in this equation is six, reflecting normal breathing with no apparent mucus retention and the ability to cough and huff.
Forced Expiratory Volume in 1 second (FEV_1), Forced Vital Capacity (FVC), and Peak Expiratory Flow Rate (PEFR) were measured with the patient in the same semi-recumbent position using an electronic hand-held spirometer "Microplus" (Sensor Medics, The Netherlands). The accuracy is ± 2% within a flow range of 2 to 12 litres per second. The maximum value for each variable of three attempts was taken for analysis. All pulmonary function variables were expressed as absolute values and as percentages of the pre-operative values.
Patients were asked to quantify the pain intensity of operation site on a Visual Analogue Scale (VAS). The patient was asked to indicate on a 10 cm horizontal line the level of pain. Pain intensity was measured at rest (VAS). After breathing exercises and coughing pain intensity was measured (VAS-F) again. The distance on the line was registered in centimetres with 1 decimal.

Study design

All measurements were performed on the pre-op day and on seven post-operative days between two and four o'clock in the afternoon. Patients participated in a prospective randomized clinical trial examining effects of three groups of post-operative analgesia: continuous epidural morphine combined with bupivacaine, continuous epidural sufentanil combined with bupivacaine, and fixed rate intramuscular morfine injections. No difference in pulmonary function between the three groups of post-operative analgesia was found (Broekema, Veen, Fidler, Gielen, and Hennis, 1998).

Statistical Analysis

Statistical analysis was performed using SPSS 10. All recorded data were taken for analysis including those of patients who were discharged or stopped

cooperating with treatment. In total six patients were discharged early or stopped their cooperation with the study. Descriptive statistics as mean and standard deviation (SD) were calculated for the following variables: FEV_1, FVC and PEFR. Median and ranges were calculated on COB, VAS and VAS-F.
For each separate day a Spearman correlation coefficient was calculated between spirometry variables and COB scores.

Results

Separate clinical items are expressed in percentages in table 2, describing a change in breathing pattern during the post-operative period. The percentage of presence of abdominal expansion is reduced in day 1 to 48. The percentage of presence of abdominal expansion is returned to 94 on day 7. Percentage of presence of paradoxical breathing is increased in the first three post-operative days; after the third post-operative day the percentage of this clinical sign is educed to preoperative levels. Clinical signs of being able to cough reduced to 20 % of pre-operative level. Sign of mucus retention is increased in the first three post-operative days.

Table 2. Separate clinical observation of breathing (COB) variable expressed as % over 7 days post abdominal surgery.

	Day -1	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Abdominal expansion (AB)	97	48	68	81	77	84	88	94
Side expansion (ST)	94	75	78	87	85	87	90	96
High thoracic expansion (HT)	96	94	99	98	100	99	100	100
Paradoxical breathing (PARA)	1	5	6	7	4	4	3	2
Symmetry of expansion (SYM)	99	99	98	98	96	97	97	99
Ability to cough (CO)	99	81	83	90	96	99	97	96
Ability to huff (HU)	100	90	92	96	99	100	97	100
Mucus retention	10	37	43	30	24	23	24	15

COB scores decreased on day 1 as compared to the pre-operative score, and increased gradually during the seven consecutive following post-operative days (table 3).

A decline in spirometry values to approximately 50% of the pre-operative values was observed on day 1. An increase was observed during the following post-operative days (table 3, figure 1); however, none of the mean values reached the preoperative values.

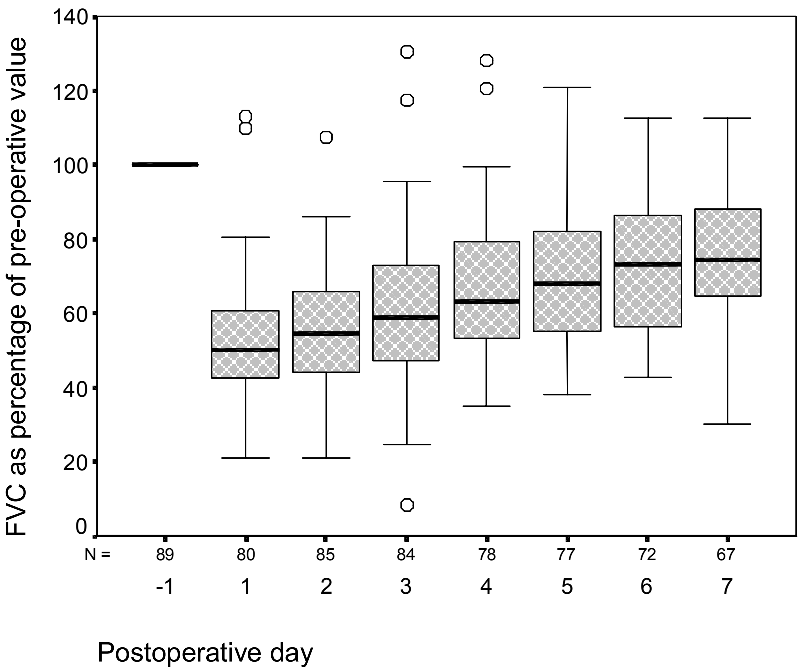

Figure 1: Boxplot of the FVC expressed as percentage of the pre-operative values on the post-operative days, outliers are shown as O.

The median (min-max) pain intensity expressed in VAS was 0 (0 - 2.5) cm on the pre-operative day. On the first post-operative day the median (min-max) VAS was 2 (0 - 10) cm. The VAS was reduced to 0.6 (0 - 4.5) cm on day 7 (table 3).

COB, median (min-max)	5 (3 - 6)	3 (1 - 5)	4 (1 - 5)	4 (1 - 6)	5 (2 - 6)	5 (2 - 5)	5 (0 - 6)	5 (2 - 6)
R. R. per minute, mean (sd)	18 (5)	21 (5)	20 (4)	19 (4)	19 (5)	19 (4)	19 (4)	20 (5)
VAS in cm, median (min-max)	0 (0 – 2.5)	2 (0 - 10)	1.5 (0 – 6.9)	0.6 (0 – 8.5)	0.55 (0 - 5.4)	0.5 (0 – 5.4)	0.8 (0 – 6.5)	0.6 (0 - 4.5)
VAS-F in cm, median (min-max)	0 (0 - 3.6)	3.6 (0 – 9.0)	2.7 (0 – 8.6)	1.7 (0 - 10)	1.3 (0 - 8)	0.9 (0 – 7.2)	1.2 (0 – 6.7)	1.2 (0 – 6.4)
FEV_1 in l/sec, mean (sd) % pre-operative	3.0 (0.9)	1.5 (0.6) 51 (15)	1.6 (0.6) 53 (15)	1.8 (0.7) 60 (19)	2.0 (0.8) 65 (18)	2.2 (1.0) 71 (27)	2.2 (0.8) 72 (18)	2.2 (0.8) 74 (18)
FVC in l, mean (sd) % pre-operative (sd)	3.6 (1.0) 100	1.8 (0.7) 52 (16)	1.9 (0.7) 54 (16)	2.1 (0.9) 60 (20)	2.3 (1.0) 66 (20)	2.5 (0.9) 70 (18)	2.5 (0.8) 72 (19)	2.7 (0.9) 76 (20)
PEFR in l/min, mean (sd) % pre-operative (sd)	430 (120) 100	213 (90) 51 (21)	217 (75) 53 (20)	261 (95) 63 (26)	294 (107) 70 (26)	319 (109) 77 (30)	328 (114) 80 (29)	331 (122) 79 (26)

The ANOVA over the pre- and 7 post-operative period showed a significant p value of < 0.001 in all variables.

FEV_1	COB SCORE	0.24* [n= 78]	0.35* [n= 81]	0.31* [n= 80]	0.25* [n= 78]	0.36* [n= 75]	0.19 [n= 70]	0.19 [n= 64]
	R.R.	-0.13 [n= 80]	-0.34* [n= 85]	-0.32* [n= 83]	-0.24* [n= 78]	-0.33* [n= 77]	-0.39** [n= 72]	-0.31* [n= 67]
	VAS	-0.25* [n= 80]	-0.33** [n= 85]	-0.26* [n= 84]	-0.14 [n= 78]	-0.19 [n= 77]	-0.25* [n= 72]	-0.18 [n= 67]
	VAS-F	-0.20 [n= 79]	-0.16 [n= 85]	-0.16 [n= 84]	-0.21 [n= 75]	-0.30* [n= 77]	-0.19* [n= 69]	-0.07 [n= 67]
FVC	COB SCORE	0.23* [n= 78]	0.35** [n= 81]	0.27* [n= 80]	0.22* [n= 78]	0.37** [n= 75]	0.16 [n= 70]	0.17 [n= 64]
	R.R.	-0.17 [n= 80]	-0.37** [n= 85]	-0.38** [n= 83]	-0.27* [n= 78]	-0.29* [n= 77]	-0.36* [n= 72]	-0.31* [n= 67]
	VAS	-0.21 [n= 80]	-0.31* [n= 85]	-0.20 [n= 84]	-0.13 [n= 78]	-0.25* [n= 77]	-0.33* [n= 72]	-0.31* [n= 67]
	VAS-F	-0.14 [n= 79]	-0.13 [n= 85]	-0.06 [n= 84]	-0.18 [n= 75]	-0.37** [n= 77]	-0.26* [n= 69]	-0.25* [n= 67]
PEFR	COB SCORE	0.17 [n= 78]	0.12 [n= 81]	0.19 [n= 80]	0.20 [n= 78]	0.37** [n= 75]	0.18 [n= 70]	0.09 [n= 64]
	R.R.	-0.13 [n= 80]	-0.19 [n= 85]	-0.15 [n= 83]	-0.20 [n= 78]	-0.26* [n= 77]	-0.33* [n= 72]	-0.28* [n= 67]
	VAS	-0.28* [n= 80]	-0.37** [n= 85]	-0.31** [n= 84]	-0.23* [n= 78]	-0.09 [n= 77]	-0.16 [n= 72]	-0.17 [n= 67]
	VAS-F	-0.33* [n= 79]	-0.42** [n= 85]	-0.20 [n= 84]	-0.30* [n= 75]	-0.16 [n= 77]	-0.10 [n= 69]	-0.03 [n= 67]

* $p < 0.05$ ** p,0.001   [n] is the exact number of patients where correlation coefficient was calculated upon.

The median (min–max) pain intensity during breathing exercises and coughing in VAS-F was 0 (0 - 3.6) on the pre-operative day. On the first post-operative day the median (min–max) VAS-F was 3.6 (0 - 9) cm. The VAS-F was reduced to 1.2 (0 – 6.4) cm on day 7 (table 3).

Relationship between clinical observation of breathing and pulmonary function:
COB and FEV_1 are significantly correlated on days 1, 2, 3, 4 and 5, COB and FVC on days 1, 2, 3, 4 and 5, and COB and PEFR on day 5 (table 4).

Relationship between pain intensity and pulmonary function:
VAS and FEV_1 are significantly correlated on days 1, 2, 3 and 6 (table 4), VAS and FVC on days 2 and 3 (table 3), VAS and PEFR on days 1, 2, 3 and 4 (table 4). Differences in exact numbers of patients and the numbers evaluated in the study are due to missing values and early discharge.

Discussion

In this study we found a significant but poor correlation among COB score, pain intensity, and pulmonary function variables. Changes in COB score and pain intensity after upper abdominal surgery underestimate the severe decline in pulmonary function in these patients. A marked decrease in pulmonary function and a decline in COB score were found after upper abdominal surgery. The recovery in pulmonary function was still incomplete seven days after surgery. Ali (Ali et al. 1974) also described a decline in pulmonary function that recovers over seven post-operative days to 70% of preoperative values. The COB score returned to the pre-operative value on day 4.
Changes in breathing pattern, such as the absence of predominant chest or abdominal movements, could indicate diaphragmatic dysfunction. Asynchronous thoracic-abdominal movements, i.e., paradoxical breathing, may indicate respiratory failure.

Non-symmetrical thoracic expansions may indicate atelectasis or pneumonia. In our study we recorded breathing pattern during voluntary maximal inspiratory effort. A maximal inspiratory manoeuvre makes movement more visible and may reflect the patient's vital capacity rather than at rest. In order to compare clinical observation of breathing with spirometry values we transferred qualitative data into ordinal quantitative data by using the equation. A limitation of this study was that the level of voluntary inspiratory effort was not quantified. Therefore we were unable to determine whether the effort was indeed the maximum and some clinical signs were not present due to lack of effort from the patients' participation. Transfer of physical assessment scores into an ordinal scoring has earlier been described by Sigg and Fallucca (Sigg & Fallucca 1983). They classified the following parameters as 0, 1, or 2: respiratory rate, respiratory pattern, depth of respiration, lung sounds, level of consciousness, colour, blood pressure, pulse, activity, pre-operative physical status (ASA). These parameters were accumulated into a total score, reflecting the presence or absence of breathing abnormalities. Our score consists of abdominal expansion, side expansion, high thoracic expansion, paradoxical breathing, symmetry of expansion, ability to cough, ability to huff, and signs of retention of sputum. We classified the scores as 0 or 1. These scores, described by Sigg and us, include parameters that are clinically used, but were not tested on validity and reliability. Nominal values as we have used are limited in comparison with ratio variables. In our equation six nominal variables, when present, are weighed positive and 2 nominal variables, when present, are weighed negative. In Table 2 we presented these variables separately. Of the positive nominal variables, high thoracic (HT) and symmetry (SYM) of expansion were seldom not present, making the equation less susceptible to changes. Nevertheless, in everyday practice these parameters are taken into consideration as well as emotional and cognitive behaviour, sweatiness, colour, and respiratory rate.

Spirometry values decreased to about 50% of pre-operative values. After 7 days these values recovered to only approximately 75% of the pre-operative value. Similar decrease in pulmonary function after abdominal surgery has been described by several authors. Hansdottir and colleagues (Hansdottir et al. 1996) found a reduction of vital capacity of approximately 50% on the first two post-operative days. Tsui (Tsui et al., 1991) described the same reduction in spirometry values in patients post oesophageal surgery during the first two post-operative days. Ali (Ali et al. 1974) described a recovery of 70% on the seventh post-operative day. The decrease in PEFR could be explained by a less forceful voluntary contraction of the abdominal muscles or reduced motivation. Cotes (Cotes, 1993) and Nunn (Nunn, 1993) describe PEFR as having an effort dependent factor due to many inhibiting elements including motivation and muscular force. A less forceful voluntary contraction of the abdominal muscles or reduced motivation may be due to pain or anxiety of pain.

We found a poor correlation between intensity of pain and decline in pulmonary function. This is in contrast with the results of the study of Taura et al. (Taura et al., 1994). Taura showed that FEV_1 was decreased in patients with VAS scores higher than 5. The mean VAS pain score of the patients in Taura's study was 3.5 cm in the treatment group and 5.3 cm in the placebo group, while the median VAS score in our study was only 2 cm. The median VAS-F during breathing exercises and couging was comparable to Taura's study. Taura did not differentiate between pain during rest and breathing exercises and coughing. In our study, patients received post-operatively pain relief for more than four days, with either continuous epidural (morphine/bupivaciane or sufentanil/bupivaciane) or fixed-rate intramuscular (morphine) pain relief. Broekema (Broekema et al. 1998) reported that post-operative analgesia at rest and during coughing and movement was significantly better in the epidural groups than in the intramuscular group during the five consecutive days. There were no significant differences between the epidural groups. If, in our analysis, pain was a limiting factor in movement and generating muscle force, then a correlation could be expected among VAS, VAS-F, and spirometry values. Our study indicates that the decline in pulmonary function after abdominal surgery is not solely the result of post-operative pain. It has been shown that other mechanisms may contribute to the decline in pulmonary function after upper abdominal surgery, such as inhibition of diaphragmatic contraction (Simonneau et al. 1983; Pansard et al. 1993) through inhibition of the phrenic nerve (Reeve et al. 1951), different operation techniques and incision sites (Ali et al. 1974; Garcia-

Valdecasas et al. 1988), and abdominal muscles impairment (Sharp et al. 1975; Duggan et al. 1989).

The validity of the COB score is poor in patients after abdominal surgery. Because of the poor correlation between intensity of pain and decline in pulmonary function values, the COB and pulmonary function tests should be used independently of the intensity of pain to determine the clinical pulmonary status. This study shows that the COB scoring is a less sensitive instrument. Only large changes in volumes may be detected during the clinical observation of breathing. The pulmonary function test can detect smaller decreases in FEV_1, FVC, and PEFR.

Conclusion

Pulmonary function after mid- and upper-abdominal surgery decreases considerably. The pulmonary function has a poor correlation with clinical observation of breathing or pain. The COB score relates poorly to pulmonary function tests because COB score is a less sensitive clinical instrument in our studied population.

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